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Conserving the fishes of the Twee River, Western Cape, South Africa: revisiting the issues

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The Twee River catchment contains two endemic fish species — the Twee River redfin and the Twee River galaxias — which are threatened by water abstraction, habitat degradation, and the presence of introduced fishes. Fyke nets were used to determine the current distribution ranges of fish in the catchment to update a 1997 survey and to provide key information for the compilation of a conservation strategy for the Twee River redfin, *Barbus erubescens*. Population estimates from 1997 placed their total number at 8 400, but population size could not be estimated from the present surveys. A number of small populations of Twee River redfin and Twee River galaxias, which are restricted to two short stretches of tributary rivers, were identified. Their long-term survival remains uncertain. Conservation action, including the eradication of alien fish and the creation of a dedicated sanctuary for the endemic populations, is recommended.

Keywords: *Barbus erubescens*, Cape Floristic Region, conservation, freshwater fish, threatened endemic fishes

Introduction

Freshwater fish communities are particularly vulnerable to the introduction of non-native species (Moyle and Light 1996) and many, if not most, of South Africa's streams and rivers have been influenced by deliberate or accidental introduction of alien fish during the last century. The potential for successful invasion is exacerbated when river systems are subjected to large disturbances, such as changes in land use (Allan et al. 1997, Allan and Johnson 1997, Allan 2004). Whilst the most effective mechanism for addressing these invasions is active prevention of introductions, in cases where non-native species have already become established, managers need to focus on reducing their harmful effects and on preventing further spread into new reaches of river systems (Richter et al. 1997).

The Olifants–Doring River system in the Western Cape Province, South Africa, is recognised as a hotspot of freshwater biodiversity and of freshwater fish endemism (Skelton et al. 1995, Skelton 2002). The Twee River sub-catchment (Figure 1) — consisting of the Suurvlei and Middeldeur Rivers and their respective tributaries, the Buffelshoek and Heks Rivers — is of particular biogeographical interest, in that it is isolated from the remainder of the system by three large waterfalls (Impson et al. 2007). The fish populations above the waterfall barriers appear to have evolved in relative isolation from those in the remainder of the catchment, as the two indigenous species of fish found here — the Twee River galaxias *Galaxias* sp. and the Twee River redfin *Barbus erubescens* Skelton 1974 — are both endemic (Hamman et al. 1984, Impson et al. 2007).

The family Galaxiidae is regarded as a Gondwanan relict within the southern temperate ichthyofauna of South Africa (Skelton 2001). Cape galaxias are distributed widely throughout the Cape Floristic Region (CFR) of South Africa. Whilst currently regarded as a single species, *Galaxias zebratus* Castelnau 1861, it is recognised that a species complex exists within it because of the large degree of morphological and genetic variation between populations (Waters and Cambray 1997, Wishart et al. 2006). The *Galaxias* of the Twee River have in turn been recognised as being morphologically and genetically distinct from other populations of *Galaxias* in the Olifants–Doring system and the CFR (Impson 2007, Impson et al. 2007) and this genus awaits taxonomic revision.

The Twee River redfin, *Barbus erubescens*, is closely related to the Clanwilliam redfin, *Barbus calidus* Barnard 1938 (Swartz et al. 2004), an Olifants–Doring endemic

(Skelton 2001) and is restricted to the Twee River catchment (Impson et al. 2007). *Barbus erubescens* was recognised by Impson et al. (2002) as a conservation priority, as it is one of the few fish species of the Cape Floristic Region's unique ichthyofauna that does not occur within a protected area. Impson et al. (2007) recorded 1 147 individuals in 1996 (of which 564 were mature) and 1 426 individuals in 1997 (of which 316 were mature) and they estimated that the population consisted of about 8 400 individuals, of which 4 100 were adults.

Invasion by introduced fish species and the impacts of farming within the catchment area have affected the Twee River catchment to the detriment of its endemic fishes. Large areas of the Suurvlei and Middeldeur catchments are intensively farmed, with deciduous fruit and citrus orchards forming the major crops. Impson et al. (2007) implicate water abstraction, application of fertilisers, pesticide runoff, and erosion in affecting water quality of the Twee River below the confluence of the Middeldeur and Suurvlei Rivers. Land owners in the catchment are aware of the unique fish assemblages and have indicated their willingness to reduce the impact of their farming practices on the river system (SMM, pers. obs.).

Within the last 60 years five species of fish have been introduced into, or have invaded, the Twee catchment (Hamman et al. 1984, Impson et al. 2007). These include three North American species: smallmouth bass, *Micropterus dolomieu* (Lacepède 1802), rainbow trout,

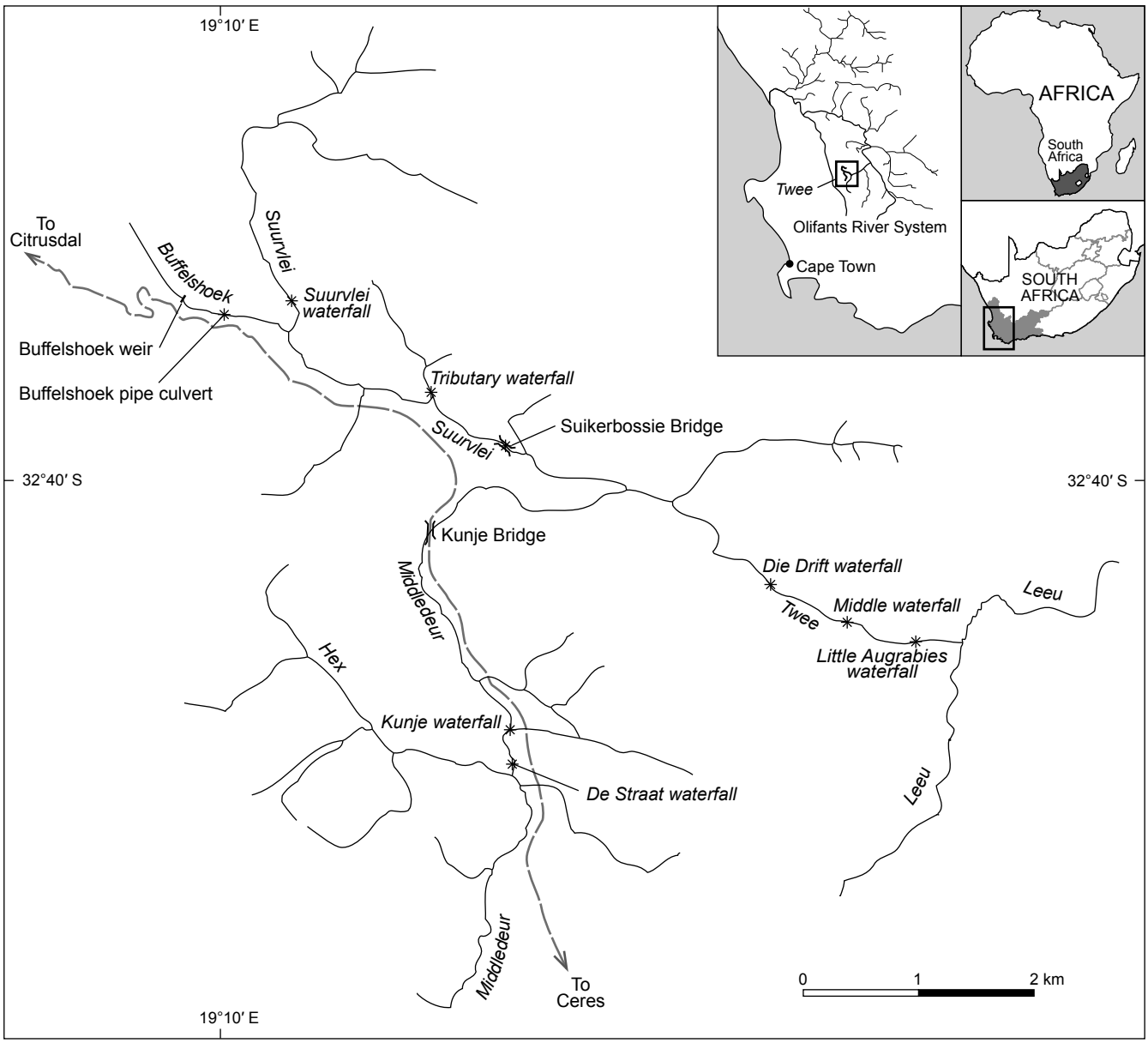

Figure 1: The Twee River catchment, showing the tributaries of the Twee River and the location of important waterfalls, roads and landmarks referred to in the text (indicated by the symbol ✳)

Oncorhynchus mykiss (Walbaum 1792), and bluegill sunfish, *Lepomis macrochirus* Rafinesque 1819. Two additional invasive species — the Clanwilliam yellowfish, *Labeobarbus capensis* (A Smith 1841) and the Cape kurper, *Sandelia capensis* (Cuvier 1831), both of which are endemic to the CFR — have also been introduced into the Twee catchment. Of these, the Cape kurper has established the largest population and invaded the largest portion of the catchment (Marriott 1998). The Olifants River System is one of the few areas in the CFR where *S. capensis* is not indigenous and anecdotal evidence dates their introduction into the Twee system to the 1950s (Hamman et al. 1984). Currently, they have invaded about three-quarters of the river length in the Twee catchment (Marriott 1998). Although all the introduced fish species in the catchment pose a threat to the remaining populations of *Galaxias* and redfin, Cape kurper may be the major threat (Hamman et al. 1984, Marriott 1998, Impson et al. 2007) because they are present in large numbers (SMM, pers. obs.), are highly territorial and strong competitors, and prey on small fish such as *Galaxias* and juvenile redfin (de Moor and Bruton 1988, Skelton 2001), as well as thriving in well-vegetated streams (J Cambray, Albany Museum, pers. comm.).

A survey was commissioned by the Western Cape Nature Conservation Board in 1996 to ascertain the conservation status of the Twee River redfin (Impson et al. 2007) and conservation actions to ensure its long-term survival were recommended (Marriott 1998, Impson et al. 2007). None of the proposed steps have yet been implemented, but the Twee River is being considered as a candidate for a project designed to evaluate the use of piscicides for eradicating alien fish in the CFR (Impson 2007).

Impson et al. (2007) summarised the conservation proposals put forward by Marriott (1998) and recommended further studies in the Twee catchment. The only subsequent work has been an unpublished preliminary survey of land-use change, instream habitat, pesticide use in the Suurvlei tributary of the Twee (Davies 2007) and survey work for the proposed fish eradication project. The present paper provides updated information on the distribution ranges of both the native and the invasive species of the Twee River and its tributaries, and summarises the current status of the Twee River redfin in the light of observed trends.

Methods

As far as possible, the study sites used by Marriott (1998) were re-visited in this study. In certain instances, when Marriott's sites were found to be densely colonised by palmiet (*Prionium striatum*), it was not possible to use these sites and alternative sites were found. Several additional sites (Figure 2) were also included for the purpose of defining the limits of fish distributions more accurately. The Suurvlei River and its tributary the Buffelshoek were visited in October 2006 and subsequent field trips in February and April 2007 covered the remaining sites.

Distribution data

The survey was completed using fyke nets, since poor visibility prevented the use of snorkelling. Nets were set overnight with the throat of the net facing upstream and the wings spanning the width of the stream. For shallow habitats we used two 600 mm D-ring twin-compartment nets with 300 mm diameter hoops and 2 mm mesh. For deeper

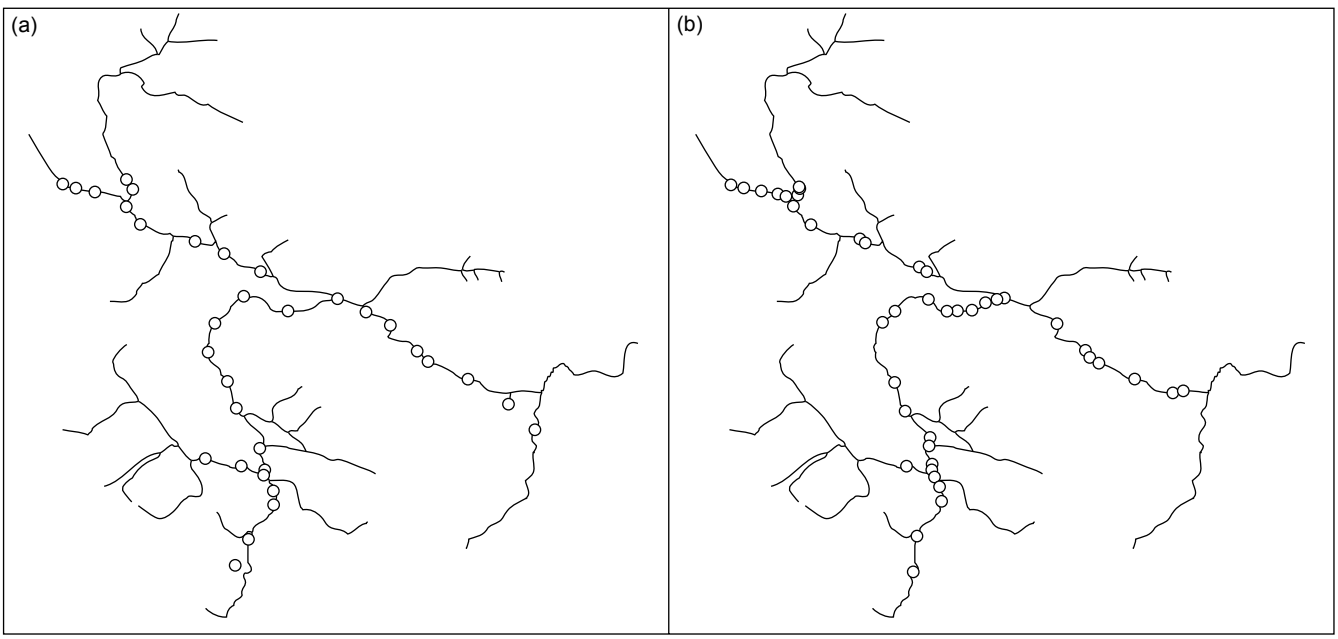

Figure 2: The Twee River catchment: location of sample sites (○) for Marriott's 1996–1997 survey (a), and the current (2006–2007) survey (b). Marriott's sites were used wherever possible, except for those now densely colonised by palmiet, *Prionium striatum*

habitats we used five 700 mm square twin-compartment fyke nets, also with 2 mm mesh. The nets were set between 17:00 and 18:00 and cleared between 08:00 and 10:00 the following morning. Alien fish were killed by a blow to the head, endemic fish were recorded and released unharmed with as little handling as possible to minimise stress. The nets were aired and dried by day to reduce the risk of organisms being transferred between the sites sampled. The coordinates of each sample site were recorded using a Garmin E-Trex Vista GPS. The resultant field records were entered into a GIS programme (Arc View 3.2) and distribution maps plotted.

Results

Maps showing the distribution of each species are presented in Figure 3, including the distributions recorded during Marriott's 1996 and 1997 surveys (as summarised by Impson et al. 2007) for comparison with data from the current survey, from which current distributions of each species were inferred. Filled circles indicate sites at which the respective species was recorded, open circles indicate sites investigated but where the respective species was not caught.

A total of six freshwater fish species was collected in the Twee River System: the endemic Twee River redfin (Figure 3a) and Twee River galaxias (Figure 3b); the translocated Cape kurper (Figure 3c) and Clanwilliam yellowfish (Figure 3d); and the introduced North American bluegill sunfish (Figure 3e) and smallmouth bass (Figure 3f). The North American rainbow trout, recorded in Marriott's 1996–1997 survey, was not collected during the current survey (Figure 3g). The numbers of individuals collected per species varied, even within sites between surveys, although the species recorded per site were consistent.

Specimens of Twee River redfin were collected from the Heks, Middeldeur, Twee and Suurvlei rivers (Figure 3a). In the Suurvlei, specimens were collected only from the uppermost reaches from which fish have previously been found and from immediately below the Suikerbossie Bridge, where one gravid female was collected in October 2006, indicating that the species might use the lower Suurvlei for breeding. No redfins were collected from the Buffelshoek River, and no juvenile redfins were captured from the upper Twee system. Their apparent absence here was not due to gear selectivity, since Twee River galaxias of the same size as juvenile redfins were captured. From the available evidence, redfin recruitment is unlikely in those reaches of the rivers surveyed that have been invaded by Cape kurper. Further investigation is required to evaluate the annual recruitment of the redfin population in the Twee River catchment.

Twee River galaxias were present in large numbers in the upper Middeldeur and Heks Rivers with isolated populations in the lower Middeldeur (Figure 3b). This species was not collected from the Suurvlei River or its tributary.

The Cape kurper was the most widespread and numerous fish species in the Twee River system (Figure 3c). Its range extended from the Kunje waterfall on the Middeldeur River, and from a raised pipe culvert on the Buffelshoek River, down to Middle waterfall on the Twee River.

Clanwilliam yellowfish were not collected above Die Drift waterfall in the current survey, although large numbers of both adults and juveniles were collected from below Die Drift waterfall downstream towards the confluence with the Leeu River (Figure 3d).

Bluegill sunfish were collected only in the lower Middeldeur, the Twee just below the confluence of the Middeldeur and Suurvlei Rivers, and in the Lower Twee River below the Little Augrabies waterfall (Figure 3e). As in Marriott's surveys, this species was not collected from the upper Middeldeur/Hex system. Smallmouth bass were collected only below Little Augrabies waterfall in the Twee River system (Figure 3f) and rainbow trout were not captured during the study (Figure 3g).

An analysis of the distribution records from the current survey showed seven distinct zones of fish assemblages in the Twee River system (Figure 4): Zone 1 is a fishless zone comprising the headwaters of the Suurvlei and Buffelshoek Rivers; Zone 2 is the redfin zone at the upper limit of fish distribution in the Suurvlei River; Zone 3 is the Cape kurper-dominated zone of the Suurvlei River to the Suikerbossie Bridge; Zone 4 is the endemic fish zone comprising the Hex River and the headwaters of the Middeldeur River to the Kunje Waterfall; Zone 5 is the Cape kurper-dominated zone of the lower Middeldeur and Suurvlei Rivers and the Twee River to the Die Drift waterfall; Zone 6 is the Clanwilliam yellowfish-dominated zone between Die Drift and Little Augrabies waterfalls, and Zone 7 is the bass-dominated zone downstream of Little Augrabies waterfall through to the confluence with the Leeu River.

The number of sample sites per zone recording each species and the number of fish captured per zone are summarised in Table 1. The corresponding data for Zones 1 to 5 from Marriott's 1996 and 1997 surveys are summarised in Table 2.

Discussion

Due to the different survey methods used, Marriott's data and that from the current surveys were not directly comparable. The present data are thus presented as distribution ranges, and no effort is made to provide population estimates for the species.

Endemic species

The distributions of the Twee River redfin and the Twee River galaxias appear not to have changed over the ten years since Marriott's survey, although both appear to have become less abundant and more localised in the lower Middeldeur and upper Twee Rivers (Zone 5). The present survey indicates that both species occur in a sanctuary above the Kunje Waterfall in the upper Middeldeur River (Zone 4). While Twee River galaxias were frequently detected in large numbers in this area, redfin numbers were low except in the reaches between the De Straat and Kunje Waterfalls. Zone 4 is clearly an important conservation area for the two endemics and it is recommended that this area be developed into a sanctuary as part of a conservation plan for the Twee River endemics.

In the lower Middeldeur and Twee rivers (Zone 5) mature adult redfins of 70–80 mm were frequently captured in the

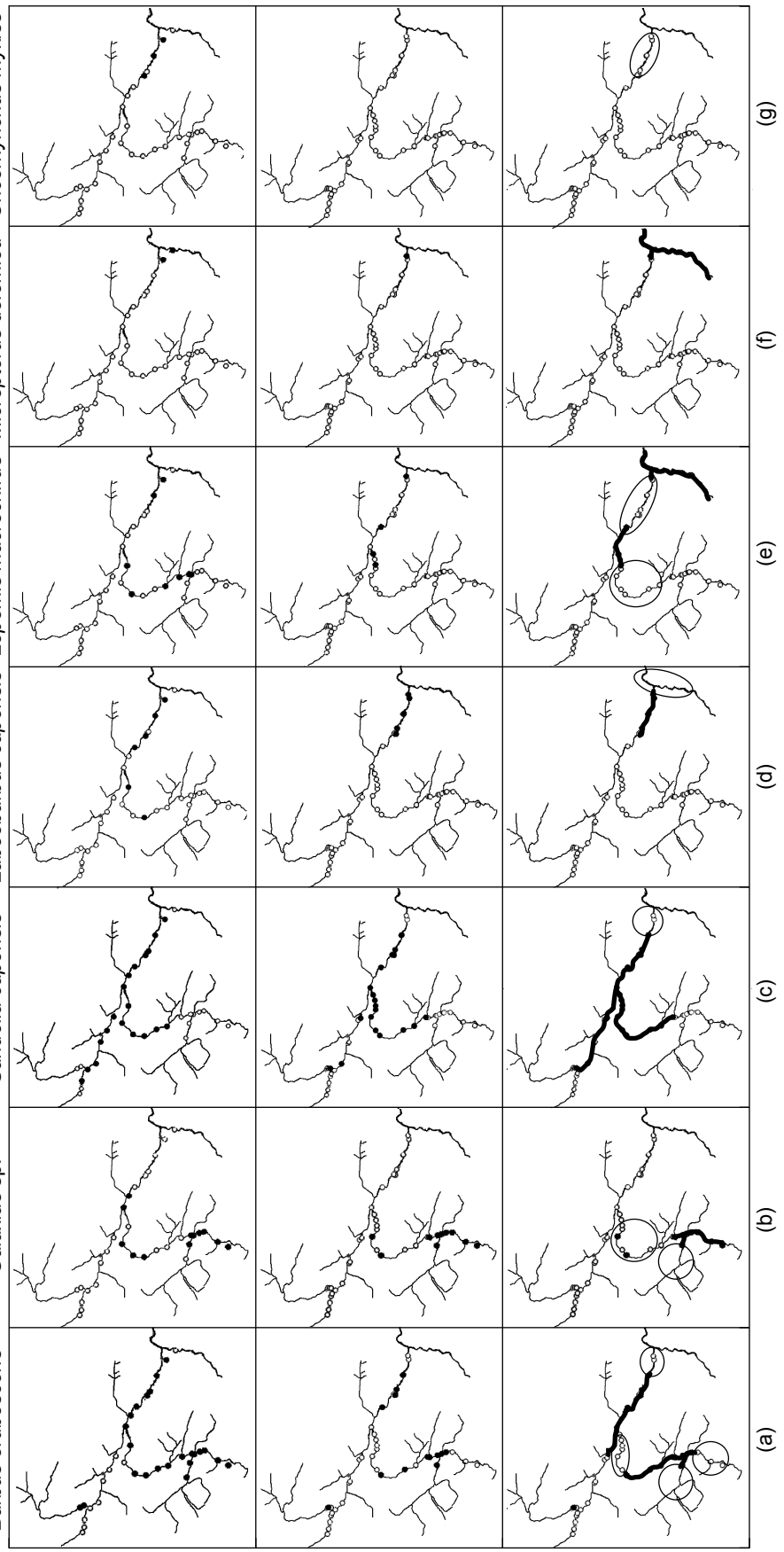

Figure 3: Site records from Marriott's (1997) and the current (2007) surveys, and current distributions as inferred from the current survey for two endemic species and five introduced species: (a) Twee River redfin (*Barbus erubescens*) (endemic); (b) Twee River galaxias (*Galaxias* sp.) (endemic); (c) Cape kurper (*Sandelia capensis*); (d) Clanwilliam yellowfish (*Labeobarbus capensis*); (e) bluegill sunfish (*Lepomis macrochirus*); (f) smallmouth bass (*Micropterus dolomieu*); and (g) rainbow trout (*Oncorhynchus mykiss*) (circled areas indicate river reaches requiring further surveys; filled circles indicate sites at which the respective species were recorded, open circles indicate sites investigated but where the respective species were not caught)

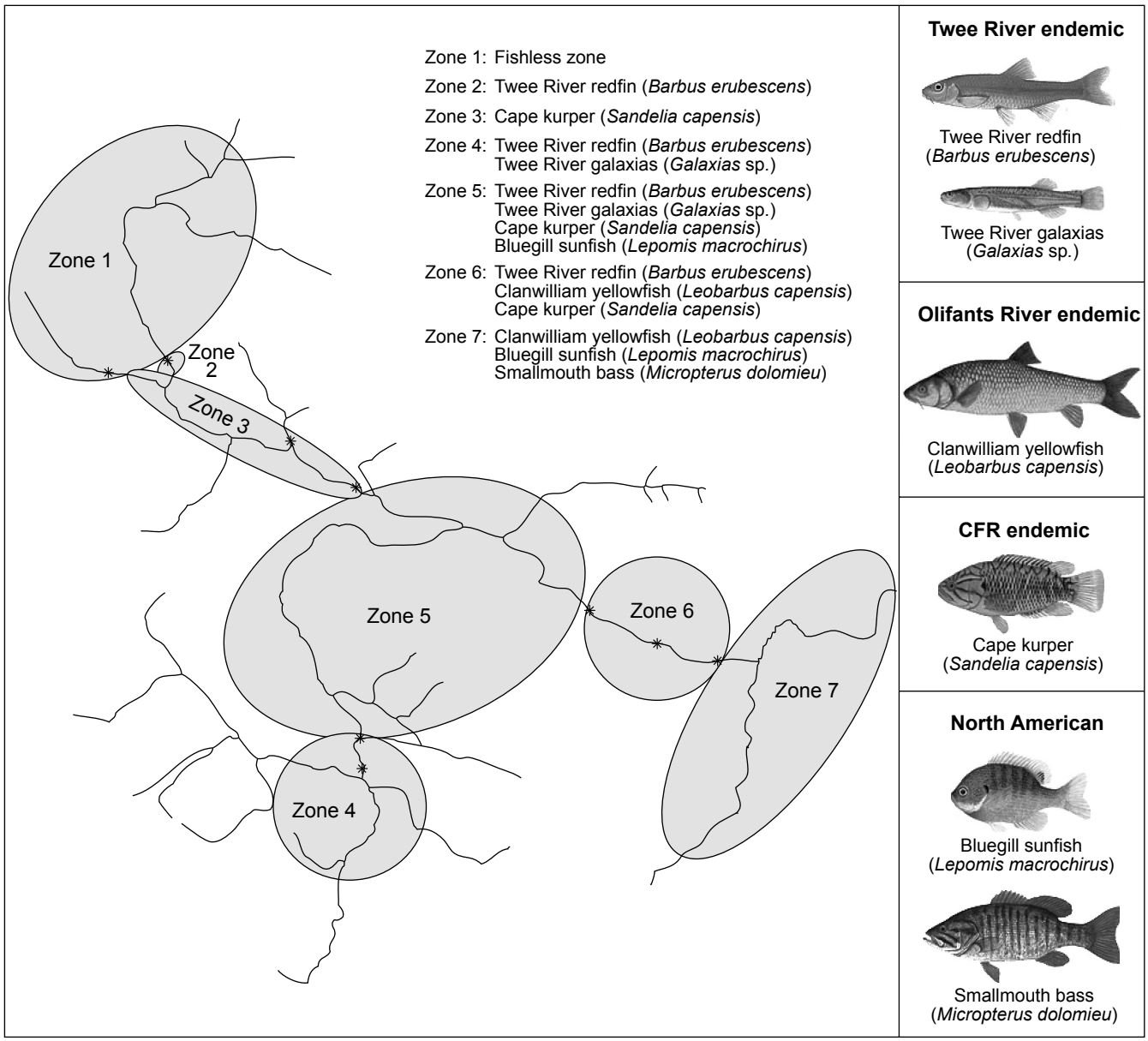

Figure 4: Zonation of the Twee River system according to the fish distribution results of the current survey (✳ represents important landmarks illustrated in Figure 1)

fyke nets, albeit in low numbers. No juveniles were captured in this zone and it is not clear if recruitment occurs in populations in these reaches. Juveniles were collected in the pool between the two sections of the Middle Waterfall in Zone 6.

The Twee River galaxias appears to be locally common at specific sites in the lower Middeldeur (Zone 5), but it was not detected further downstream in the Twee River. This species was recorded at fewer sites than in the 1996 and 1997 surveys. Further surveys are required to confirm the distribution and size of its populations in the lower Middeldeur and upper Twee (Zone 5) and to establish whether recruitment occurs at these river sites.

Introduced species

The Cape kurper appears to have reached the full extent of its invasion. The distribution of the population is currently bounded by the Kunje Waterfall on the Middeldeur River, a pipe culvert on the Buffelshoek River, and an unidentified barrier on the Suurvlei River. Fishermen are unlikely to translocate Cape kurper as it is not considered an angling fish. It might move downstream into the Leeu River, but smallmouth bass below the Little Augrabies waterfall currently form a possible biological barrier preventing kurper from extending downstream into the Doring system.

Bluegill sunfish appear to have established recruiting populations in the lower Middeldeur River (Zone 5). This is

Table 1: Number of fyke net sites recording each species, and number of fish (in parentheses) caught per zone in the Twee River system from the present study. Zones are described in the text and illustrated in Figure 4

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7[1]
Total number of sites	4	2	9	11	14	5	1
Species	Number of sites at which species was recorded (number of fish caught for each species)						
Barbus erubescens (Twee River redfin)	0 (0)	2 (14)	1 (3)	5 (97)	4 (101)	4 (36)	0 (0)
Galaxias sp. (Twee River galaxias)	0 (0)	0 (0)	0 (0)	9 (188)	2 (73)	0 (0)	0 (0)
Sandelia capensis (Cape kurper)	0 (0)	0 (0)	8 (271)	0 (0)	14 (501)	4 (109)	0 (0)
Labeobarbus capensis (Clanwilliam yellowfish)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)[2]	5 (151)	1 (2)
Lepomis macrochirus (bluegill sunfish)	0 (0)	0 (0)	0 (0)	0 (0)	3 (39)	0 (0)	1 (0)[3]
Oncorhynchus mykiss (rainbow trout)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Micropterus dolomieu (smallmouth bass)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)[3]
Site at which no fish were captured	4	0	1	2	0	0	0
Site at which 'otters' damaged net	0	0	0	4	1	0	0

[1] Only one net was set in Zone 7, and therefore the numbers of individuals per species collected there may not fully represent the proportions of these species within the zone, or represent all the species present in the zone

[2] Subsequent to this study, one Clanwilliam yellowfish was captured in Zone 5 above the Die Drift waterfall

[3] Subsequent to this study, bluegill sunfish (4) and smallmouth bass (24) were captured by angling and electrofishing in Zone 7

Table 2: Number of fyke net sites recording each species, and number of fish caught (in parentheses) per zone in Marriott's 1996–1997 study (Marriott 1998). Zones are described in the text and presented in Figure 4

	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5	
Survey year	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997
Number of sites	3	3	2	2	4	4	9	9	10	10
Species	Number of sites at which species recorded (number of fish recorded for each species)									
Barbus erubescens (Twee River redfin)	0 (0)	0 (0)	2 (250)	2 (50)	0 (0)	0 (0)	9 (367)	6 (617)	7 (290)	4 (479)
Galaxias sp. (Twee River galaxias)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (756)	7 (186)	3 (7)	4 (50)
Sandelia capensis (Cape kurper)	1 (3)	0 (0)	0 (0)	0 (0)	3 (13)	2 (246)	0 (0)	0 (0)	9 (563)	9 (788)
Labeobarbus capensis (Clanwilliam yellowfish)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (6)	0 (0)
Lepomis macrochirus (bluegill sunfish)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (50)	1 (2)	3 (8)	0 (0)
Oncorhynchus mykiss (rainbow trout)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Micropterus dolomieu (smallmouth bass)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Site at which no fish were captured	2	3	0	0	1	2	0	1	0	1

a matter of concern, as bluegill have proven to be invasive elsewhere in the world (Marchetti 1999), South Africa (de Moor and Bruton 1988) and in the CFR (Impson et al. 2002). It is thus likely to have adverse long-term effects on the Twee River endemics. At present bluegill numbers are low, probably due to the large population of kurper present in this zone. The establishment of a large population of bluegill in Zone 5 could lead to the local extirpation of Twee River redfin and Twee River galaxias from this zone due to predation on eggs, larvae and juveniles as found in California by Marchetti (1999) for the Sacramento perch.

The current survey did not detect bluegill sunfish in Zone 4, even though they were recorded in this zone during the previous study. Although the source of the bluegill in

this catchment has not been established, a number of dams in Zone 4 may hold bluegill populations and further survey work is required to check this.

Clanwilliam yellowfish were not detected above Die Drift waterfall during the current study but they thrive in Zone 6, forming a large self-sustaining population that provides a source of yellowfish for the Doring system. The presence of yellowfish in the reaches between Die Drift and Little Augrabies waterfalls (Zone 6) is a matter of concern (R Bills, South African Institute for Aquatic Biodiversity, pers. comm.) since these reaches consist of what is considered to be prime redfin habitat, with the highest population densities of redfin being observed in these reaches during Marriott's, and subsequent, surveys. Furthermore, it has been suggested that yellowfish are outcompeting, and possibly preying on, redfin in this area (R Bills, pers. comm.) although this hypothesis is unconfirmed. Further research is required to determine the interactions between the endemic and the introduced species of the Twee River system.

Rainbow trout were not detected during the current survey and appear not to have formed a naturalised population in the Twee River.

Bass species identification in the lower Twee River

Samples of bass (*Micropterus* spp.) collected in the lower Twee River were difficult to identify because some specimens showed the characteristics of both smallmouth and spotted bass. Smallmouth bass (*Micropterus dolomieu*) and spotted bass (*Micropterus punctulatus*) co-occur in the lower Twee, where the two species appear to be hybridising (SMM, pers. obs.), although this has not yet been confirmed by genetic analysis. Hybrids between smallmouth and spotted bass have been recorded in the USA (Koppelman 1994, Cofer 1995) and it has been suspected that these species have hybridised elsewhere in the Olifants–Doring system (Bills 1999). Bass were only found downstream of the natural distribution range of the Twee River redfin and are not currently viewed as a threat to the endemic fish species of the Twee system.

Conclusion

This study provides an overview of the current status of the Twee River redfin population. Their increasing localisation and apparent reduction in abundance over the last ten years point to a deterioration in the long-term population security for both the Twee River redfin and the Twee River galaxias. As concluded by both Marriott (1998) and Impson et al. (2007), the presence of Cape kurper and bluegill in the Suurvlei and Middeldeur systems poses the greatest threat to the endemic species (Impson et al. 2007). However, the synergistic effect of the decline in habitat quality due to farming activities should not be underestimated. Whilst it is not within the scope of this paper to produce a complete review of the conservation options for the Twee River system, it is clear that a conservation action plan, with detailed species recovery plans, is needed in order to secure the future of the Twee River redfin and the endemic Twee River galaxias populations. Further survey work must be done to investigate the impact not only of invasive fish, but also of land use and pesticide runoff from the surrounding farmland on the endemic fish species and aquatic macroinvertebrates. Conservation authorities should encourage land owners to develop a sanctuary for the endemic species in Zone 4, including a monitoring programme to regularly assess the status of the invasive fish species. Additional refuges for the endemic species could also be created by stocking them into dams in this catchment.

The Twee River catchment, as a sanctuary for its endemic species, is in the balance. Appropriate and immediate action, engaging both social and biological aspects of conservation, is now critical in order to avert the loss of this unique freshwater assemblage.

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